

BI/SCANTM I

RECORDS AND REPRODUCES:

- Transient
- Random
- Continuous...signals from *D.C. to 40 kc.*

USE IT TO CONVERT:

- Non-periodic Data to Periodic Functions with High Duty Cycles and High Repetition Rates... up to 60 times/second, power line synchronous.

IDEALLY SUITED FOR:

- Transient Analysis and Display
- Random Data Analysis
- SNR Enhancement of Non-Periodic Signals
- Real-Time Enhancement of Periodic Signals
- Signal Delay for Correlation Studies.

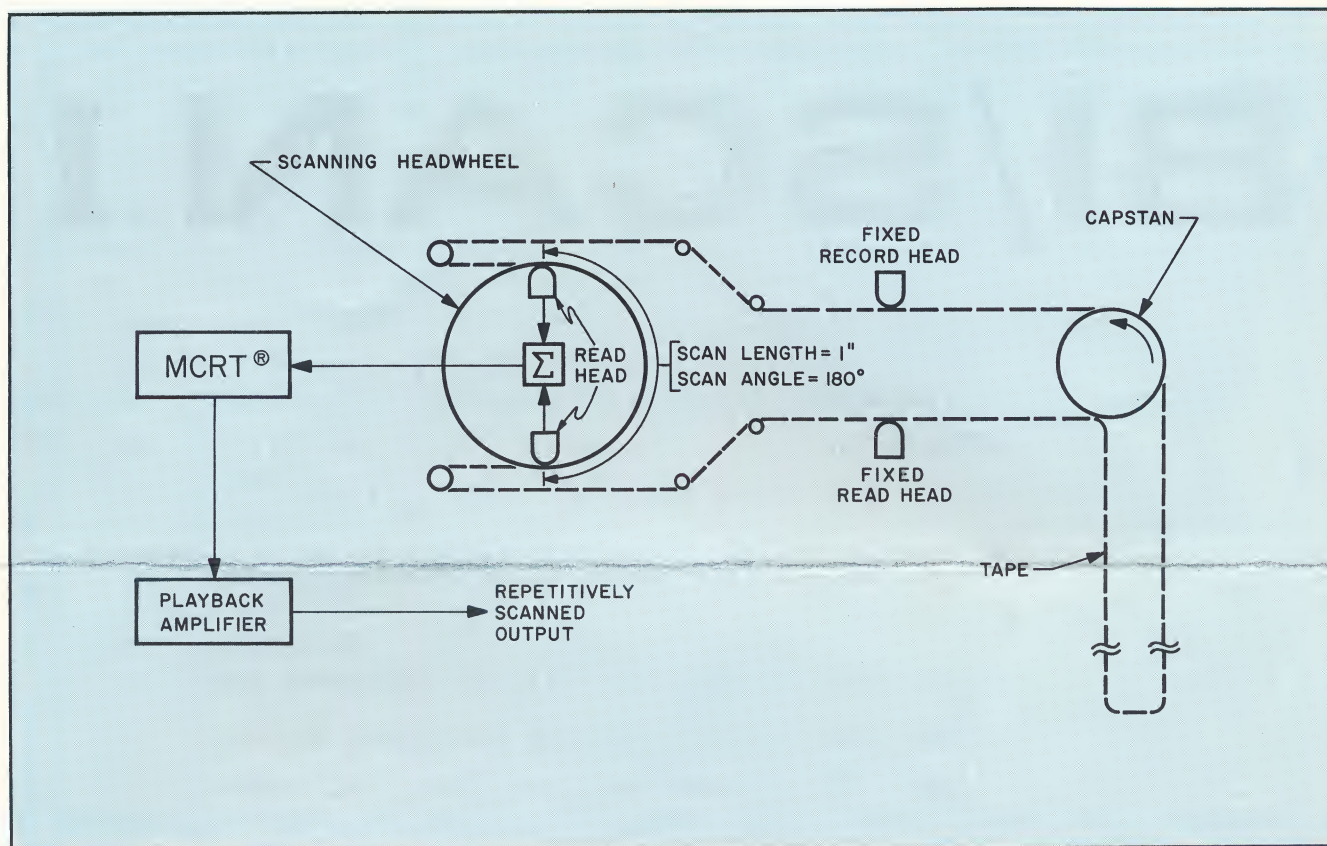
GENERAL DESCRIPTION: BI/SCAN is a new magnetic tape system combining the unique capabilities of S. Himmelstein and Company's VI/SCANTM and IMPELLORTM equipments. It will record random and/or transient signals and convert them into periodic functions which can be analyzed by conventional techniques—see Application Note for a discussion of BI/SCAN signal enhancement capabilities.

BECAUSE playback is possible in either of two modes—as a loop device for long data segments or

as a fast scanning headwheel for very short (transient) data—optimum handling is provided for a large range of non-repetitive data. The scanning headwheel can be operated with the tape in motion or stopped. Thus, real-time processing is possible. The flexibility obtained permits BI/SCAN to be used in a variety of unusual data storage/processing applications—including speech compression. The simplified functional diagram will help visualize BI/SCAN operation. Detailed system specifications follow.

S. HIMMELSTEIN AND COMPANY

2500 ESTES AVE., ELK GROVE VILLAGE, ILLINOIS 60007 • TELEPHONE (312) 439-8181



BI/Scan Simplified Functional Diagram

BI/SCAN's high headwheel scan rate (60 times per second) and high maximum loop rate (6.7 times per second) *significantly decreases processing times needed by more conventional devices and/or yields higher processing gains*. IRIG 1/2" wide tape standards are used to record and reproduce two independent data channels in the FM mode. Thus, recordings made on an IRIG instrumentation deck can be processed on BI/SCAN and vice versa. When desired, the recording function may be used to re-record (or dub) data stored on another tape machine.

THE EQUIPMENT conforms to the highest instrumentation standards. The IMPELLOR II all-pneumatic loop transport is used to assure long loop life and obtain high performance. It eliminates wear-causing pinch rollers and tensioned mechanical rollers found in conventional tape loop devices. IMPELLOR's drive, tensioning and buffering systems are vacuum operated for gentle tape handling. The scanning

headwheel uses a thin, stable air film between the headwheel and tape which virtually eliminates wear. S. Himmelstein and Company MCRT's® (Multi-Channel Rotary Transformers) are used for low noise, long life signal coupling from the rotating headwheel.

The IMPELLOR Subsystem may be used independently of the scanning headwheel. Under those conditions, it provides the high performance and superior, low-wear tape handling characteristics of the basic transport. When equipped with optional adjustable head positioners, it can be used to generate wide bandwidth, wide range channel-to-channel time delays for correlation analysis. All control circuits are interlocked for tape protection during headwheel scanning. The rotating headwheel is a plug-in component and may be interchanged with optional, extra cost, headwheels with up to 8" scan lengths. Special, four-track headwheels can be supplied.

Headwheel Subsystem Characteristics

ONE DUAL-CHANNEL, plug-in headwheel is provided. It is capable of reading $\frac{1}{2}$ " wide tapes recorded in the IRIG FM format. IRIG tracks three (3) and five (5) are standard. The 1" scan length is ideal for transient data analysis, i.e., short transients are made periodic with a high duty cycle avoiding the substantial loss in processing time and loss in overall signal-to-noise ratio that occurs when such transients are cycled on a tape loop.

The high scan rate—60 scans/second—guarantees

that the output signal will be within the operating frequency range of the majority of signal analysis devices. Furthermore, the scan rate, which is locked to power line frequency, yields stable, flickerless oscilloscope displays of scanned data. The tape wrap angle adjustment permits optimum setting for each application. A combination safety/dust cover encloses the headwheel and fixed head assemblies and protects operating personnel. Headwheel/tape motion controls are located above the deck.

Standard System Parameters

Heads: All magnetic head stacks conform to IRIG standards, i.e., azimuth angle is $90^{\circ}00' \pm 1'$, effective track width is $0.050" \pm 0.002"$, track spacing is $0.140" \pm 0.002"$, gap scatter is $\pm 0.00005"$. Channels 3 and 5 are provided. Heads are all metal construction.

Wow and Flutter: Angular flutter of the headwheel, with tape in motion or stopped is 0.6% peak-to-peak maximum, measured over a bandwidth from 0.5 to 10,000 cps.

Scan Length: Circumferential gap-to-gap spacing is $1.000" \pm 0.002"$.

Scan Angle: 180° , nominal. Two gaps are spaced at 180° increments around the headwheel periphery.

Tape Wrap Angle: The angle between points of tangency is adjustable from 170° to 190° .

Scan Direction: Unidirectional; information recorded first is scanned first.

Scan Rate: 60 scans per second assuming 60 cps line frequency. The Scan Rate is power line synchronous.

Scanning Speed: Peripheral velocity of the headwheel is $60.0 \text{ ips} \pm .20\%$, assuming 60 cps line frequency.

Loop Transport Characteristics

A MODIFIED IMPELLOR II Transport is an integral part of this system. IMPELLOR II is a six speed all-pneumatic loop transport equipped for handling 1/2" wide tape. Standard equipment includes one 50' loop cartridge and two channel record and reproduce head stacks. The record headstack is mounted, with post guides, in the upper baseplate position. As noted above, IRIG tracks 3 and 5 are standard. Tape speeds are 240, 120, 60, 30, 15, and 7.5 ips; all $\pm 0.25\%$ at 60 cps line frequency. There are two belt selected speed ranges; within either range, a front panel switch

selects any of the three available speeds. Tape motion (RUN/STOP) may be controlled from illuminated push button switches on the front panel or, remotely, via contact closures. For convenience in locating recorded transients, a tape SEARCH mode permits the operator to manually advance tape into the headwheel scan area during scanning. The maximum loop rate is 6.7 times per second using a 36" tape loop at 240 ips. The loop rate is proportionately lower at lower tape speeds. An optional head positioner allows synthesis of delays for correlation studies.

FM Record/Reproduce Electronics

RECORD/PLAYBACK circuitry is solid state. Modular, expandable construction is used. Center frequency determining networks and output filters are plug-in. Two channels of record and reproduce circuits are provided with plug-in networks for the six operating speeds. The reproduce circuits may be used either for the fixed or scanning systems. Record system bandwidth versus tape speed is tabulated below. Response is flat within ± 0.5 db over the stated bandwidths and SNR is at least 40 db at all speeds.

TAPE SPEED	SYSTEM BANDWIDTH
7.5 ips	D.C. — 1.25 kc
15 ips	D.C. — 2.5 kc
30 ips	D.C. — 5.0 kc
60 ips	D.C. — 10 kc
120 ips	D.C. — 20 kc
240 ips	D.C. — 40 kc

BECAUSE THE HEADWHEEL scanning speed is fixed at 60 ips, its output bandwidth is fixed at dc—10 kc regardless of record bandwidth.

Controls: Fully interlocked loop and headwheel manual controls are provided for the following functions: HEADWHEEL—RUN & STOP, TAPE LOOP—SPEED, RUN, STOP, and SEARCH. Tape motion can be remotely controlled by floating contact closure.

Size: 19" wide, 17 1/2" high, and 18 1/8" deep (behind front panel).

Power Requirements: 110 volts $\pm 10\%$ @ 60 cps. 9 amperes, maximum.

Price: \$13,615.00 or \$13,800.00 installed in cabinet. Prices are f.o.b. Elk Grove Village, Illinois.

Terms: 1/2 % ten days, net 30 days.

Delivery: 17-20 weeks after receipt of order.

BI/SCAN Application Note

Using BI/SCAN to Detect Signals Buried in Noise

General

Most methods for detecting signals masked by noise depend on narrow band filtering techniques. When the noise is random -- has uniform spectral density -- the presence of a signal will increase the energy at the frequency (or frequencies) of the signal and, as a result, the presence of the signal can be detected and its spectral components measured. This is the basic technique used in signal enhancement by Spectrum Analysis, Power Spectral Density Analysis, Correlation Analysis (or Matched Filtering), etc.

The narrower the filter bandwidth, the greater the processing gain. In other words, the deeper down a signal buried in noise can be detected. This procedure depends on the signal being periodic. It cannot be employed for non-periodic signals. BI/SCAN can be used for handling non-periodic signals which are otherwise impossible to detect and analyze. BI/SCAN can also be used to improve the processing gain for continuous signals -- in real-time. Its use is outlined in the following paragraphs.

Detecting Non-Periodic Signals in Noise

If the noise-obscured data is recorded on a tape loop and played back continuously, it is made periodic at the loop rate. Furthermore, because the background noise is random -- has uniform spectral density -- repeating it does not alter it, i.e., it remains random. Therefore, it is possible to locate non-periodic signals made periodic with a tape loop by conventional analysis methods such as Spectrum Analysis, Power Spectral Density Analysis, etc. This technique has been well established for the analysis of non-periodic signals buried in noise.

As the bandwidth of the analyzing filter is decreased, the processing gain is increased, i.e., the signals can be detected deeper in noise and discrete resonant peaks that are close together can be separated. As a practical matter, steep skirted filters with a bandwidth of much less than 1 cps are unattainable. Most 1 cps filters are sophisticated tracking devices which operate at relatively high frequencies -- the construction of very narrow bandwidth low frequency filters is impractical. Thus, it is virtually impossible to detect low frequency, noise-obscured data with the same processing gains possible at higher frequencies.

This dilemma can be solved using magnetic tape for frequency multiplication and then processing the multiplied data through practical filters. Under these conditions, the filter looks at the original data with an equivalent bandwidth equal to its own bandwidth divided by the multiplication ratio. For example, if data is multiplied in frequency 100 times and then analyzed by a 1 cps filter, the original data is being processed in 0.01 cycle bands. This technique has been used successfully for extremely narrow band analysis of very low frequency (sub-sonic) data as well as for the synthesis of extremely narrow band filters. BI/SCAN is uniquely suited for

such application because it is a very high performance loop machine (240 ips tape speed) capable of large, stable multiplication ratios and, because it incorporates a unique, low-wear tape handling system that can read-out loops many thousands of times without signal degradation.

Detecting and Analyzing Noise-Obscured Transients

The same technique -- converting to a periodic function -- can be used for detecting and analyzing noise-obscured transients. However, even when recorded on the high speed IMPELLOR loop, short transients will occupy a very small percentage of the loop. The resultant low duty cycle reduces the overall processing gain and makes the technique virtually useless.

BI/SCAN solves this problem by incorporating a headwheel in the tape path which repetitively scans a one inch length of tape 60 times per second. Thus, in effect, it creates a tape loop only one inch long. It reads transients with good duty cycles and at a high rate -- line synchronous for stable, flickerless, oscilloscope presentations. Because the transient is made repetitive at a high rate, it can be processed by all conventional narrow band analyzers, detected in a noise background and/or broken down into its composite spectral components.

Real-Time Detection of Periodic Signals

Consider the case where a continuous time function (sine wave or other) is buried in noise and cannot be found because practical filters do not have adequate processing gain. If such a signal is recorded on BI/SCAN and scanned by the headwheel, the filter bandwidth can be significantly reduced provided the record and playback conditions are arranged to obtain frequency multiplication (see above discussion). Although not immediately obvious, the frequency multiplication -- and therefore, the processing gain -- can be increased by heterodyning the input signal down in the frequency spectrum.

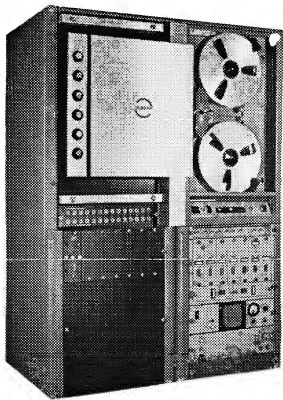
Heterodyning merely displaces the input data in the frequency spectrum -- it does not divide frequency, alter phase coherence, or have any other similar effect. Heterodyning is also valid for those situations where the data is higher in frequency than BI/SCAN's recording capability (0-40 kc).

Thus, radio frequency signals can be heterodyned down, recorded on BI/SCAN, repetitively read-out with a large frequency multiplication and detected by conventional narrow band filters -- all in real-time. It is interesting to note for radio signals the suggested heterodyning would actually be the second, for most superheterodyne receivers, or as much as the fourth, for more sophisticated receiver designs. None of these frequency "translations" have any deleterious effect on the signal.

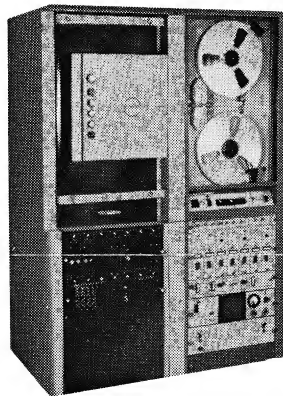
For a more detailed discussion with illustrative examples, write for the Technical Memorandum entitled, "A New Technique for Transient Data Analysis and Signal-To-Noise Ratio Enhancement."

VI/SCAN™ AND IMPELLOR™

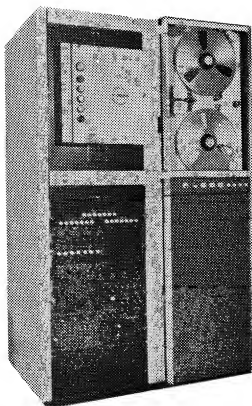
UNIQUE MAGNETIC TAPE DATA PROCESSING AND RECORDING SYSTEMS



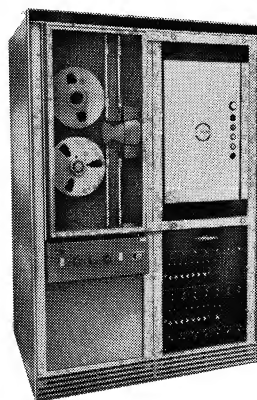
VI/SCAN I



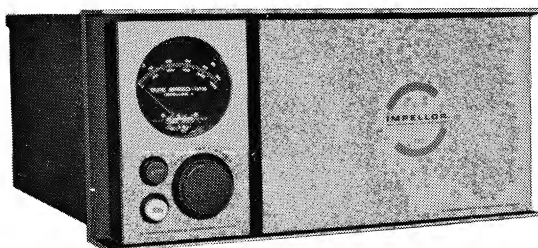
VI/SCAN II



VI/SCAN III



VI/SCAN IV



IMPELLOR I

VI/SCAN — Repetitive
longitudinal tape scanner

IMPELLOR — High
performance magnetic tape loop
record/reproduce system

Records and Reproduces:

- Transient data
- Random data
- Continuous data

Converts:

- Non-periodic Data to Periodic Functions with High Duty Cycles and High Repetition Rates . . . up to 60 times/second, power line synchronous.

Ideally Suited For:

- Transient Analysis and Display
- Fast Power Spectral Density Studies
- SNR Enhancement of Non-periodic Signals
- Correlation Analysis
- Frequency Multiplication and Division
- Wideband Delay Synthesis
- Recirculating Digital Memories
- Transient and Fault Recording

Write or phone for additional descriptive literature

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